CLAIMS

1. A process for forming a metal film on a surface of a diffusion barrier layer, the process comprising:

providing the surface of the diffusion barrier layer wherein the surface is comprised of at least one material selected from the group consisting of a metal, a metal carbide, a metal nitride, a metal carbonitride, a metal silicon carbide, a metal silicon nitride, a metal silicon carbonitride, and a mixture thereof and wherein the at least one surface is substantially free of an elemental metal; and

forming the metal film on the at least one surface using at least one organometallic precursor,

provided that when the surface of the diffusion barrier layer (i) has the at least one material that is the metal, (ii) has an orientation other than a substantially (111) preferred orientation, (iii) has less than 95% of a (111) preferred orientation and/or (iv) comprises at least one material selected from a metal nitride, a metal carbide, a metal carbonitride, and mixtures thereof having less than a stoichiometric amount of nitrogen and/or carbon atoms relative to metal atoms contained therein, then a step of exposing the at least one surface to an at least one adhesion promoting agent selected from the group consisting of a nitrogen, a nitrogen-containing compound, a carbon-containing compound, a carbon and nitrogen containing compound, a silicon-containing compound, a silicon and carbon containing compound, a silicon, carbon, and nitrogen containing compound and a mixture thereof is conducted.

2. The process of claim 1 wherein the exposing step is conducted.

3. The process of claim 2 wherein the exposing step is conducted prior to the forming step.

4. The process of claim 2 wherein the exposing step is conducted during at least a portion of the forming step.

5. The process of claim 1 wherein the forming step comprises at least one process selected from the group consisting of chemical vapor deposition or atomic layer deposition.

6. The process of claim 5 wherein the chemical vapor deposition is at least one process selected from the group consisting of thermal chemical vapor deposition, plasma enhanced chemical vapor deposition, remote plasma enhanced chemical vapor deposition, plasma assisted chemical vapor deposition, cryogenic chemical vapor deposition, chemical assisted vapor deposition, hot-filament chemical vapor deposition, photo-initiated chemical vapor deposition, and combinations thereof.

7. The process of claim 1 wherein said diffusion barrier layer is a metal nitride selected from the group consisting of chromium nitride, tantalum nitride, titanium nitride, tungsten nitride, molybdenum nitride, zirconium nitride, vanadium nitride, and mixtures thereof.

8. The process of claim 1 wherein said diffusion barrier layer is a metal carbide selected from the group consisting of chromium carbide, tantalum carbide, titanium carbide, tungsten carbide, molybdenum carbide, zirconium carbide, vanadium carbide, and mixtures thereof.

9. The process of claim 1 wherein said diffusion barrier layer is a metal selected from the group consisting of chromium, tantalum, titanium, tungsten, molybdenum, zirconium, vanadium, and mixtures thereof.

10. The process of claim 1 wherein said diffusion barrier layer is a metal carbonitride selected from the group consisting of chromium carbonitride, tantalum carbonitride, titanium carbonitride, tungsten carbonitride, molybdenum carbonitride, zirconium carbonitride, vanadium carbonitride, and mixtures thereof.

11. The process of claim 1 wherein said diffusion barrier layer is a metal silicon nitride selected from the group consisting of tantalum silicon nitride, titanium silicon nitride, molybdenum silicon nitride, and mixtures thereof.

12. The process of claim 1 wherein said diffusion barrier layer is a metal silicon carbide selected from the group consisting of tantalum silicon carbide, titanium silicon carbide, and mixtures thereof.

13. The process of claim 1 wherein said diffusion barrier layer is a metal silicon carbonitride selected from the group consisting of silicon carbonitride, titanium silicon carbonitride, tantalum silicon carbonitride, and mixtures thereof.

14. The process of claim 1 wherein said organometallic precursor is non-fluorinated.

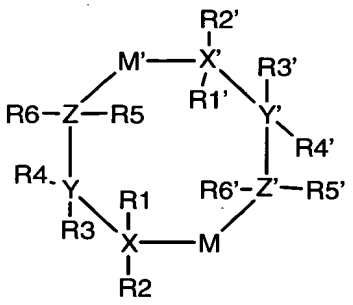
15. The process of claim 1 wherein said organometallic precursor is fluorinated.

16. The process of claim 15 wherein said organometallic precursor comprises hexafluoroacetylacetonate.

17. The process of claim 1 wherein said organometallic precursor comprises an organometallic copper precursor.

18. The process of claim 17 wherein said organometallic copper precursor is 1,1,1,5,5,5-hexafluoro-2,4-pentanedionato-copper (I) trimethylvinylsilane.

19. The process of claim 1 wherein said organometallic precursor is a compound represented by the following structure (I):



(I)

wherein M and M' are each Cu, Ag, Au, Ir, Ru, Rh, or Re;

X and X' are each N or O;

Y and Y' are each Si, C, Sn, Ge, B, or Al;

Z and Z' are each C, N, or O; R1, R2, R1', and R2' are each independently a hydrogen, an alkyl, an alkenyl, an alkynyl, a partially fluorinated alkyl, an aryl, an alkyl-substituted aryl, a partially fluorinated aryl, a fluoralkyl-substituted aryl, a trialkylsilyl, or a triarylsilyl when X and X' are N;

R1 and R1' are each independently an alkyl, an alkenyl, an alkynyl, a partially fluorinated alkyl, an aryl, an alkyl-substituted aryl, a partially fluorinated aryl, a fluoralkyl-substituted aryl, a trialkylsilyl, or a triarylsilyl when X and X' are O;

R3, R4, R3', and R4' are each independently a hydrogen, an alkyl, a partially fluorinated alkyl, a trialkylsilyl, a triarylsilyl, a trialkylsiloxy, a triarylsiloxy, an aryl, an alkyl-substituted aryl, a partially fluorinated aryl, a fluoroalkyl-substituted aryl, or an alkoxy; and

R5, R6, R5', and R6' are each independently a hydrogen, an alkyl, an alkenyl, an alkynyl, a partially fluorinated alkyl, an aryl, an alkyl-substituted aryl, a partially fluorinated aryl, a fluoralkyl-substituted aryl, a trialkylsiloxy, a triarylsiloxy, a trialkylsilyl, a triarylsilyl, or an alkoxy;

provided that when X and X' are each O, there is no substitution at R2 and R2';

further provided that when Z and Z' are each N, there is no substitution at R6 and R6';

further provided that when Z and Z' are each O, there is no substitution at R5, R6, R5', or R6';

said alkyl and alkoxide having 1 to 8 carbons; said alkenyl and alkynyl having 2 to 8 carbons; and said aryl having 6 carbons.

20. The process of claim 1 wherein the metal film comprises a substantially (111) preferred orientation.

21. The process of claim 1 wherein the metal film is a seed layer.

22. The process of claim 1 wherein the metal film comprises at least one metal selected from the group consisting of copper, platinum, cobalt, nickel, palladium, ruthenium, rhodium, iridium, gold, silver, and mixtures thereof.

23. A substrate comprising a metal film produced by the process of claim 1.

24. A process for forming a substantially continuous copper film on a surface of a diffusion barrier layer, the process comprising:

providing a substrate comprising the surface of the diffusion barrier layer wherein the surface is comprised of an at least one material selected from the group consisting of a metal, a metal carbide, a metal nitride, a metal carbonitride, a metal silicon nitride, a metal silicon carbide, a metal silicon carbonitride, and a mixture thereof;

exposing the surface of the diffusion barrier layer to an at least one adhesion promoting agent selected from the group consisting of a nitrogen, a nitrogen containing compound, a carbon containing compound, a carbon and nitrogen containing compound, a silicon-containing compound, a silicon and carbon containing compound, a silicon, carbon, and nitrogen containing compound, and a mixture thereof; and

forming the copper film on at least a portion of the surface using an organometallic copper precursor.

25. The process of claim 24 wherein the at least one material is the metal carbide, the metal nitride, the metal carbonitride, the metal silicon nitride, the metal silicon carbide, and the metal silicon carbonitride.

26. The process of claim 24 wherein the surface of the diffusion barrier layer comprises less than 95% of a (111) preferred orientation.

27. The process of claim 24 wherein the surface of the diffusion barrier layer comprises an orientation other than the (111) preferred orientation.

28. The process of claim 24 wherein the at least one material is the metal.

29. The process of claim 24 wherein the surface of the diffusion barrier layer comprises at least one material selected from a metal carbide, a metal nitride, and a metal carbonitride wherein the amount of carbon and/or nitrogen is less than the stoichiometric amount of metal within the at least one material.

30. A process for forming a substantially continuous metal film on a surface of a diffusion barrier layer, the process comprising:

depositing the diffusion barrier layer onto a substrate wherein the surface of the diffusion barrier layer comprises an at least one material selected from the group consisting of a metal carbide, a metal nitride, a metal carbonitride, a metal silicon carbide, a metal silicon nitride, a metal silicon carbonitride, and a mixture thereof and wherein the surface comprises a substantially (111) preferred orientation; and

forming the metal film on at least a portion of the surface using an at least one organometallic precursor.

31. The process of claim 30 further comprising exposing the surface of the diffusion barrier layer to an at least one adhesion promoting agent selected from the group consisting of a nitrogen, a nitrogen containing compound, a carbon containing

compound, a carbon and nitrogen containing compound, a silicon-containing compound, a silicon and carbon containing compound, a silicon, carbon, and nitrogen containing compound, and a mixture thereof.

32. The process of claim 30 wherein the metal film comprises at least one metal selected from the group consisting of copper, platinum, cobalt, nickel, palladium, ruthenium, rhodium, iridium, gold, silver, and mixtures thereof.

33. The process of claim 32 wherein the metal film has a (111) preferred orientation.

34. A process for forming a substantially continuous metal layer on a surface of a diffusion barrier layer, the process comprising:

providing a substrate comprising the diffusion barrier layer wherein the surface of the diffusion barrier layer is comprised of an at least one material selected from the group consisting of a metal, a metal carbide, a metal nitride, a metal carbonitride, a metal silicon nitride, a metal silicon carbide, a metal silicon carbonitride, and a mixture thereof;

exposing the surface of the diffusion barrier layer to an adhesion promoting agent selected from the group consisting of a nitrogen, a nitrogen containing compound, a carbon-containing compound, a carbon and nitrogen containing compound, a silicon-containing compound, a silicon and carbon containing compound, a silicon, carbon, and nitrogen containing compound, and a mixture thereof; and

growing a metal halide layer on the surface of the diffusion barrier layer by contacting the surface with a halogen-containing precursor and an organometallic precursor wherein the halogen and the metal within the precursors react to form the metal halide layer; and

exposing the metal halide layer to a reducing agent to provide the metal layer.

35. A process for forming a substantially continuous metal layer on an at least one surface of a diffusion barrier layer, the process comprising:

providing a substrate comprising the diffusion barrier layer within a vacuum chamber wherein the at least one surface of the diffusion barrier layer is substantially free of an elemental metal;

introducing an at least one organometallic precursor into the vacuum chamber; and

applying energy to the at least one organometallic precursor to induce reaction of the at least one organometallic precursor and deposit the metal layer on the at least one surface of the diffusion barrier layer.

36. The process of claim 35 further comprising exposing the at least one surface of the diffusion barrier layer with at least one agent selected from the group consisting of a nitrogen, a nitrogen containing compound, a carbon containing compound, a carbon and nitrogen containing compound, a silicon-containing compound, a silicon and carbon containing compound, a silicon, carbon, and nitrogen containing compound, and a mixture thereof.

37. The process of claim 36 wherein the exposing step is conducted prior to the forming step.

38. The process of claim 36 wherein the exposing step is conducted during at least a portion of the forming step.

39. The process of claim 35 wherein the providing step comprises depositing the diffusion barrier layer comprising a metal nitride, a metal carbide, a metal carbonitride, a metal silicon nitride, a metal silicon carbide, a metal silicon carbonitride, and a mixture thereof.

40. The process of claim 35 wherein the diffusion barrier layer comprises a substantially (111) preferred orientation.

41. A process for forming a substantially continuous metal film on a surface of a diffusion barrier layer, the process comprising:

depositing the diffusion barrier layer onto a substrate wherein the surface of the diffusion barrier layer comprises an at least one material selected from a metal carbide, a metal nitride, a metal carbonitride, and a mixture thereof and wherein the surface of the diffusion barrier layer comprises a stoichiometric amount or greater of carbon and/or nitrogen relative to metal contained within the at least one material; and

forming the metal film on at least a portion of the surface using an at least one organometallic precursor.

42. A process for forming a substantially continuous metal film on a surface of a diffusion barrier layer, the process comprising:

depositing the diffusion barrier layer onto a substrate wherein the surface of the diffusion barrier layer is comprised of at least one material selected from a stoichiometric tungsten nitride with a (100) preferred orientation, a stoichiometric tungsten nitride with a (111) preferred orientation, a stoichiometric tungsten nitride which is amorphous, a stoichiometric tungsten nitride which is polycrystalline, a non-stoichiometric tungsten nitride having a greater amount of nitrogen atoms than tungsten atoms contained therein, and a mixture thereof; and

forming the metal film on at least a portion of the surface using an at least one organometallic precursor.

43. The process of claim 42 wherein the surface is comprised of stoichiometric tungsten nitride with a (100) preferred orientation.

44. The process of claim 42 wherein the surface is comprised of stoichiometric tungsten nitride with a (111) preferred orientation.

45. The process of claim 42 wherein the surface is comprised of non-stoichiometric tungsten nitride having a greater amount of nitrogen atoms than tungsten atoms contained therein.